

The Significance of Computed Tomography–Detected Breast Lesions

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ABSTRACT

Introduction: With ever-increasing computed tomography (CT) utilisation, more breast lesions are incidentally detected. We sought to investigate the yield of undiagnosed cancers from incidental CT-detected breast lesions. Imaging features were compared with the pathological diagnoses.

Methods: A retrospective analysis of CT examinations in a regional hospital in Hong Kong between January 2018 and December 2020 was performed. Patients without a history of breast diseases whose CT reports contained the keyword 'breast' and who were referred for a formal breast examination were included. Two radiologists reviewed the CT reports and lesion characteristics were recorded. The diagnostic accuracy of different CT features was evaluated.

Results: A total of 219 breast lesions were included. Forty-eight lesions (21.9%) were malignant. Patients with malignant diagnoses were older in age than those with benign diagnoses (mean age: 67.58 vs. 56.60 years; $p = 0.05$). Spiculation, irregularity, rim and heterogeneous enhancement, as well as the presence of abnormal lymph nodes were useful in predicting malignancy. Lesion size and presence of calcifications were not useful for predicting the pathological diagnosis.

Conclusion: More than 20% of breast lesions detected incidentally in CT examinations were malignant. The presence of spiculation and irregularity were positive predictive factors. A careful review of the breasts on CT studies including the chest should always be part of routine practice.

Key Words: Breast; Breast neoplasms; Diagnostic imaging; Incidental findings; Lymph nodes

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中文摘要

電腦斷層掃描檢測到乳腺病變的重要性

林樂宜、朱嘉敏、曾凱晴、衛穎莊、趙朗峰

引言：隨着電腦斷層掃描使用愈趨普及，越來越多的乳腺病變被偶然發現。我們調查電腦斷層掃描偶然檢測到的乳腺病變中未確診癌症的發生率，並比較影像學特徵與病理診斷。

方法：我們就2018年1月至2020年12月期間香港某地區醫院的電腦斷層掃描檢查進行回顧性分析。本研究納入沒有乳腺疾病史而電腦斷層掃描報告中包含「乳腺」關鍵字並轉診進行正式乳腺檢查的患者。兩名放射科醫生審查了電腦斷層掃描報告。本研究記錄了患者的病變特徵，並評估不同電腦斷層掃描特徵的診斷準確性。

結果：本研究共納入219個乳腺病灶，48個病變（21.9%）為惡性。診斷為惡性病變的患者年齡比診斷為良性病變的患者年齡大（平均年齡：67.58歲與56.60歲； $p = 0.05$ ）。毛邊、不規則、邊緣和不均勻強化以及異常淋巴結的存在有助預測惡性腫瘤。病灶大小和鈣化的存在無助預測病理診斷。

結論：電腦斷層掃描檢查偶然發現的乳腺病變中20%以上為惡性。存在毛邊和不規則是陽性預測因素。透過電腦斷層掃描檢查仔細檢查胸部乳腺應成為常規。

INTRODUCTION

Breast cancer is one of the commonest cancers in Hong Kong, comprising 28.4% of female cancers in 2020.¹ In Hong Kong, mammography and sonography are the preferred initial modalities in the evaluation of breast lesions.² In some other countries, mammography is the mainstay for breast cancer screening.³ In an era with increasing utilisation of computed tomography (CT), more breast lesions are detected incidentally when CT scanning is performed for other indications such as pulmonary or cardiac conditions.⁴⁻⁶ Although dedicated mammography and sonography are still required for a better evaluation of the lesions, it is still important for radiologists to detect imaged breast lesions and to characterise them when such lesions are encountered on a CT scan. With an increased detection of undiagnosed breast cancer, a prompt referral of suspicious lesions for further investigation can help improve patient outcome. We aimed to investigate the yield of breast cancers from incidentally detected breast lesions on CT in Hong Kong. Their imaging features were correlated and compared with the final pathological diagnoses.

METHODS

A retrospective analysis of the CT examinations scanned in Queen Elizabeth Hospital from 1 January 2018 through 31 December 2020 was performed. Patients whose CT reports contained the keyword 'breast' and were referred

for a formal breast examination were included. The CT reports were derived from the Radiological Information System and Picture Archiving and Communication System, which is a system managed by Hospital Authority. Patients who had a history of breast diseases or breast surgeries were excluded from the study.

The CT scanners used in this study included SOMATOM Force Ultra-Fast Dual Source CT Scanner (Siemens Healthcare, Erlangen, Germany), Aquilion CXL 128 Slice CT Scanner (Toshiba, Tochigi, Japan), and Aquilion Prime CT Scanner (Canon Medical Systems, Tochigi, Japan), with a section thickness of 5 mm. The types of contrast used for enhanced procedures were iohexol (Omnipaque 350; GE HealthCare, Milwaukee [WI], US) and iodixanol (Visipaque 320; GE HealthCare, Milwaukee [WI], US), with a standard adult dose of 90 mL, administered via a pump injector. In examinations of the abdomen requiring injected contrast material imaged in different phases, the contrast was administered for the arterial phase at 3.5 mL/s or in the portal venous phase at 2.5 mL/s with a standard 70-second delay.

The CT images were reviewed by and commented on by two experienced radiologists (with 6 and 8 years' experience in breast imaging, respectively) who were blinded to the diagnostic outcome. As there is no formal lexicon for breast lesions detected in a CT scan, the

descriptors used in this study were adapted from the Breast Imaging and Reporting Data System terminology for magnetic resonance imaging lexicons (5th edition).^{7,8} The axillary lymph nodes were considered abnormal if: (1) their longest-to-shortest axis ratio was <2; (2) they lacked a fatty hilum; (3) there was cortical thickening of >3 mm; or (4) their cortices were eccentric.⁹

Continuous variables were presented as mean ± standard deviation, and categorical variables were presented as frequencies. The Mann-Whitney *U* test was used to evaluate the distribution of continuous data. Fisher's exact test was performed to assess the correlation of the CT features with final pathological diagnosis. The specificity and sensitivity for malignancy were calculated for the significant CT features. A *p* value of < 0.05 was considered to be statistically significant.

RESULTS

Demographics and Study Cohort

A total of 22,255 CT studies of the thorax with or without abdominal regions were performed during the study period. Among these CT examinations, 2,575 of the reports contained the keyword 'breast'. A total of 347 patients without history of prior breast disease or surgery were noted to have one or more incidental breast lesions in the CT studies; 345 were women and two were male. A total of 224 patients were referred for further formal breast assessment and investigation, among which 188 had subsequent formal breast investigations, nine had defaulted appointments, and 27 were still pending appointments at the time of the study. Among these 188 patients (186 female and 2 male), 164 patients had a solitary lesion, while 17 patients had two lesions and seven patients had three lesions, for a total of 219 incidentally detected breast lesions (Figure 1).

Referral Rates

The overall referral rate for formal breast investigations during the study period was 64.6%. It was lowest in 2018 (61.0%) and highest in 2019, which was 70.8%.

Formal Breast Assessment Findings

Among the 219 breast lesions undergoing formal breast assessment, 88 were classified as 'normal' or 'with benign appearance' by clinical examination, mammography, and ultrasonography. The remaining 100 patients have undergone ultrasound-guided biopsy in our institute. In these patients, 83 lesions were found to be benign and 48 lesions were malignant (Figure 2), most of which were invasive ductal carcinoma (Table 1).

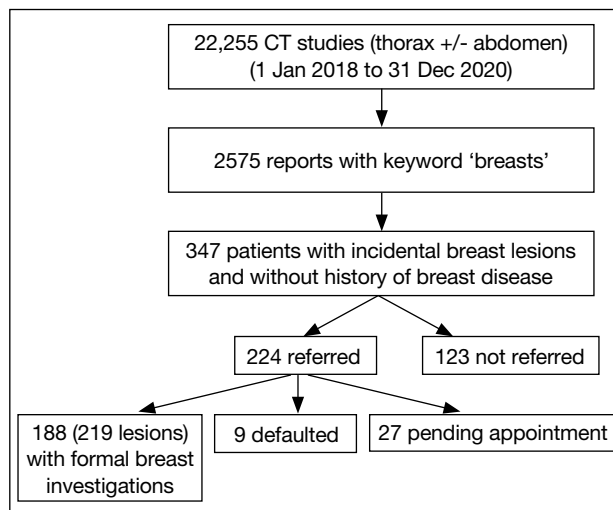


Figure 1. Patient selection.

Abbreviation: CT = computed tomography.

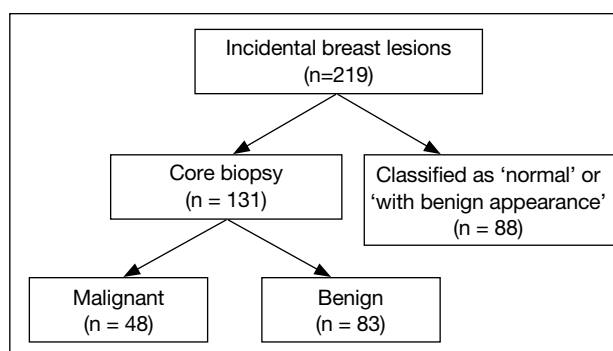


Figure 2. Results of formal breast assessments.

Table 1. Core biopsy pathology of incidental breast lesions (n = 131).

	No.
Benign	83
Fibroadenoma	31
No evidence of malignancy	29
Fibrocystic changes	7
Apocrine cyst	5
Sclerosing adenitis	4
Hamartoma	2
Intraductal papilloma	2
Atypical ductal hyperplasia	1
Benign phyllodes tumour	1
Gynaecomastia	1
Malignant	48
IDC	34
DCIS	10
LCIS	2
ILC	1
Malignant spindle cell tumours	1

Abbreviations: DCIS = ductal carcinoma in situ; IDC = invasive ductal carcinoma; ILC = invasive lobular carcinoma; LCIS = lobular carcinoma in situ.

Table 2. Morphology and enhancement patterns of the breast lesions (n = 219).

	Lesion		Malignancy rate	p Value
	Malignant (n = 48)	Benign (n = 171)		
Shape				< 0.001
Oval	8	74	9.8%	
Round	28	94	23.0%	
Irregular	12	3	80%	
Margin				< 0.001
Circumscribed	22	148	12.9%	
Indistinct	18	23	43.9%	
Spiculated	8	0	100%	
Contrast enhancement				0.001
No enhancement	0	59	0%	
Homogeneous enhancement	27	72	27.3%	
Heterogeneous enhancement	9	2	81.8%	
Rim enhancement	3	0	100%	

Table 3. Diagnostic performance of suspicious computed tomography features in the differentiation of malignant from benign incidental breast lesions.

	Sensitivity	Specificity	PPV	NPV
Irregular shape (n = 15)	25%	98.2%	80%	82.4%
Non-circumscribed margin (n = 49)	54%	86.5%	53.1%	87.1%
Spiculated margin (n = 8)	16.6%	100%	100%	81%
Contrast enhancement (n = 113)	100%	44.4%	34.5%	100%

Abbreviations: NPV = negative predictive value; PPV = positive predictive value.

The malignancy rate was 21.9% (48 out of 219 lesions). Patients with malignant lesions were likely to be older in age compared with those with benign findings (mean age: 67.58 vs. 56.60 years, $p = 0.05$).

Lesion Characteristics

CT measurement showed that the malignant lesions (mean size: 1.56 cm) were larger than the benign lesions (mean size: 1.23 cm) but not statistically significant ($p = 0.08$). Among the morphological characteristics of the breast lesions (Table 2), more lesions with an irregular shape or non-circumscribed margin were diagnosed as malignant ($p \leq 0.001$). The malignancy rate (i.e., positive predictive value [PPV]) of all irregular lesions was 80%. The sensitivity and specificity of an irregular shape were 25% and 98.2%, respectively, while the malignancy rate of all non-circumscribed lesions was 53.1%. The calculated sensitivity and specificity of a non-circumscribed margin were 54% and 86.5%, respectively. Among the two descriptors for non-circumscribed margins, a spiculated margin had a malignancy rate of 100% with sensitivity and specificity of 16.6% and 100%, respectively, and is more indicative of malignancy ($p < 0.05$) [Table 3 and Figure 3].

Four biopsy-proven malignant lesions contained calcification. However, the association between calcification and malignancy of the lesions was not statistically significant ($p > 0.05$) [Table 4 and Figure 4].

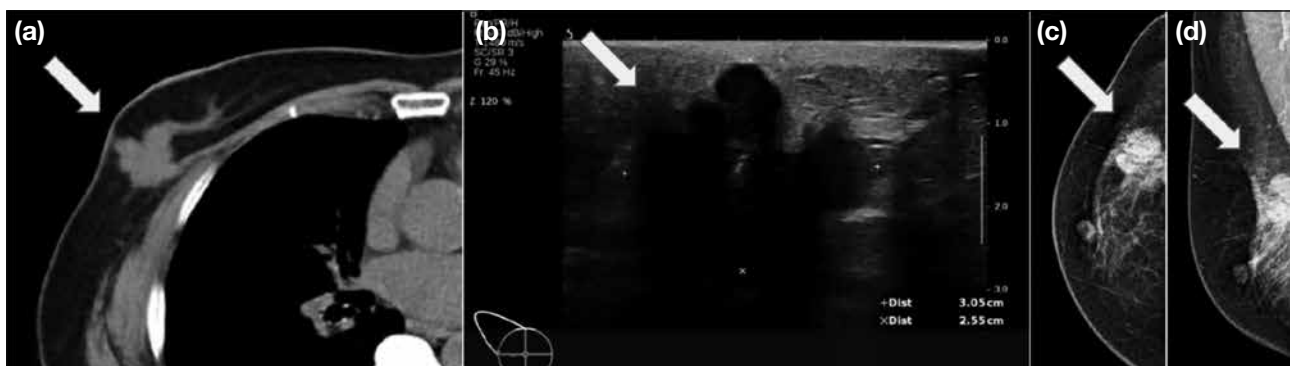


Figure 3. A 67-year-old woman underwent a plain computed tomography (CT) scan of the thorax for prolonged cough. (a) Axial CT scan reveals an incidental irregular shaped mass with spiculated margins in the upper outer quadrant of the right breast (arrow), with suspicious involvement of the right pectoralis muscle. (b) Ultrasound scan of the right breast confirms the hypoechoic mass with irregular shape and spiculated margin at the right 9 o'clock position (arrow). (c, d) Mammograms showing the right breast mass as a high-density irregular mass with spiculated margins that closely abuts the pectoralis muscle (arrows). Biopsy was performed and pathological examination confirmed invasive ductal carcinoma.

Table 4. Presence of abnormal axillary lymph nodes or calcifications in the breast lesions (n = 219).*

	Lesion		p Value
	Malignant (n = 48)	Benign (n = 171)	
Abnormal axillary lymph nodes			< 0.001
Present	12	7	
Not present	20	87	
Calcification			1
Present	44	154	
Not present	4	17	

* In some of the computed tomography scans, the axilla were not included in the scan range.

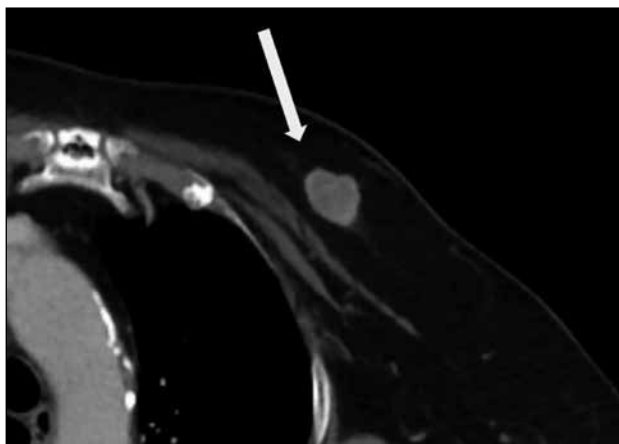


Figure 4. A 59-year-old woman underwent a contrast-enhanced computed tomography scan of the thorax for shortness of breath. An incidental breast mass showing peripheral enhancement is seen in the upper part of the left breast (arrow). Subsequently she underwent biopsy in the private sector that revealed invasive ductal carcinoma.

Contrast Enhancement

A total of 172 lesions were evaluated in contrast-enhanced CT scans, with 113 of them showing contrast enhancement (Table 2). All of the malignant lesions showed enhancement. The sensitivity and specificity of contrast enhancement were 100% and 44.4%, respectively, for a negative predictive value of 100% for lack of enhancement (Table 3). Furthermore, all lesions that showed rim enhancement were malignant, giving a malignancy rate of 100% ($p < 0.05$) with specificity of 100% (Table 2 and Figure 5).

Presence of Axillary Lymph Nodes

The axillary regions were included in the CT scan range in 126 patients. A total of 19 patients were found to have abnormal axillary lymph nodes, of which 12 of them have biopsy-proven malignant breast lesions. The association between presence of abnormal-looking axillary lymph nodes and breast malignancy was found to be statistically significant ($p < 0.001$) [Table 4].

DISCUSSION

Our study shows an increase in referral rate for dedicated breast imaging from 2018 to 2020, with increased reporting of CT-detected breast lesions. Despite a similar number of total CT scans done in our institute annually, this may be due to an increased awareness of CT-detected breast lesions leading to referral to the breast imaging units for characterisation.

In our study, 21.9% of the incidental CT-detected breast

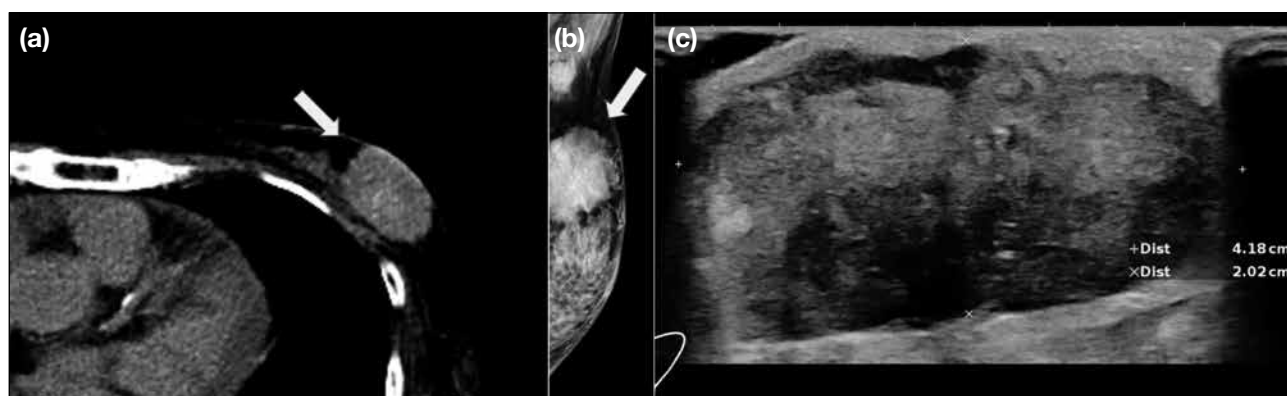


Figure 5. A 60-year-old woman with a contrast-enhanced computed tomography scan of the abdomen for abdominal pain. (a) An incidental breast mass with lobulated shaped and circumscribed margins is seen at the upper outer quadrant of the left breast with subtle internal calcifications (arrow). (b) Mammography showing a high-density, irregularly shaped mass with spiculated margins and internal pleomorphic calcifications (arrow). (c) Sonography showing the large left breast mass with internal echogenic foci suggestive of calcifications. This mass was later biopsied and confirmed to be invasive ductal carcinoma.

lesions were proven to be malignant after biopsy in the breast unit, i.e., out of the 22,255 CT studies performed in 2018 to 2020, 43 patients (five of them with more than one incidental breast tumour) were ultimately diagnosed with unsuspected breast cancer. Hence, the extrapolated breast cancer detection rate by CT scans is 1.9 cases per 1000 population based on our findings. A retrospective review by a local public hospital performed in the 5-year period from 1998 to 2002 showed that the breast cancer detection rate by mammogram is 5 cases per 1000 population,² in agreement with the concept that CT scan alone is not a better screening test than mammography.

Of the incidentally detected breast cancers in our study, most cases were invasive ductal carcinoma (70.8%) [Table 1], similar to the incidence of invasive ductal carcinoma in the general population of 75%.^{10,11} Ductal carcinoma in situ accounted for 20.8% of the incidentally detected breast cancers in our study (Table 1). Although CT lacks the resolution for microcalcifications, these cases were detected as breast masses.¹²

The most suspicious features for malignancy were found to be an irregular shape (malignancy rate of 80%) and spiculated margin (malignancy rate of 100%) [Table 2]. These results were in keeping with other studies across different modalities including mammography and sonography. Liberman et al¹³ reported a PPV for malignancy of 73% for irregular shape and 81% for spiculated margins for mammographic studies. Inoue et al¹⁴ reported a PPV for malignancy of 99% for irregular shape and 100% for spiculated margins for CT using dynamic dedicated breast CT. Stavros et al¹⁵ reported a PPV for malignancy of 91.8% for spiculated lesions on sonography.

On the other hand, we found that oval shape (malignancy rate of 9.8%) and circumscribed margins (malignancy rate of 12.9%) are more indicative of benignity (Table 2). These results are also similar in the study by Moyle et al.¹⁶

The presence of CT-detected calcifications in breast lesions does not show a statistically significant association with the final pathology diagnosis (Table 4). In this study, only four biopsy-proven malignant lesions contained calcification, while the other visible calcifications were associated with benign entities. This is likely due to the fact that CT has limited spatial resolution. Microcalcifications <0.5 mm that are more likely associated with malignancy cannot be detected

on non-dedicated CT.¹⁷ Lindfors et al¹⁸ found that CT was worse than mammography for visualisation of microcalcifications.

In our study, all of the biopsy-proven breast malignancies showed contrast enhancement with different enhancement patterns. Among these patterns, rim enhancement and heterogeneous enhancement were more indicative of malignancy (malignancy rate of 100% and 81.8%, respectively) [Table 2]. These results are similar to the findings by Moyle et al¹⁶ and Agrawal et al¹⁹ but are opposite from the study by Inoue et al,¹⁴ who made use of dedicated breast CT for their study. The discrepancy can be due to the difference in timing of image acquisition in the CT studies in our study. Also, malignant breast tumours show rapid contrast uptake and washout, which is well known as a type 3 curve.²⁰ However, one limitation of our study is that the timing of the contrast administration was not fixed for all the CT studies, therefore such contrast enhancement pattern cannot be demonstrated.

In our study, the association between the presence of abnormal-looking axillary lymph nodes and breast malignancy was found to be statistically significant (Table 4). Therefore, evaluation of axillary lymph nodes is essential as part of the triple assessment and before sentinel lymph node biopsy. Although axillary ultrasound is more convenient, it is found that the combination of axillary ultrasound, breast CT, and magnetic resonance imaging of the breast yields a better accuracy rate than the use of a single imaging modality.²¹

CONCLUSION

The breasts are an area for review by CT radiologists, as more breast lesions are being detected incidentally in CT examinations. This study has shown that nearly one in four incidental breast lesions leads to a diagnosis of breast cancer, particularly in older adults, lesions demonstrating spiculation, irregularity or rim enhancement, and in the presence of abnormal axillary lymph nodes. The detection of these incidental lesions can facilitate a timely referral for a formal breast examination, prompt patient management, and better disease outcome.

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